

Celebrating the Neutrino 1

The Reines-Cowan Experiments—Detecting the Poltergeist 4

A compilation of papers and notes by Fred Reines and Clyde Cowan, Jr.

The neutrino's existence was inferred by Wolfgang Pauli in 1930, who feared that his clever construct might elude detection forever. Twenty-five years later, Fred Reines, Clyde Cowan, Jr., and a Los Alamos team detected the evasive particle. Their dedication to the chase and their innovative detection techniques set a precedent for all future neutrino experiments.

Beta Decay and the Missing Energy 7

Fermi's Theory of Beta Decay and Neutrino Processes 8

The Oscillating Neutrino—An Introduction to Neutrino Masses and Mixing 28

Richard Slansky, Stuart Raby, Terry Goldman, and Gerry Garvey as told to Necia Grant Cooper

Today, the neutrino is at the center of particle physics as experimenters around the world explore the possibility that this tiny particle changes its identity just by moving between two points. The mixing among neutrino identities would signal to physicists that neutrinos have mass. It would also suggest that efforts to find a unified theory of all the fundamental forces of nature are on the right track.

Neutrino Masses—How to Add Them to the Standard Model 64

Stuart Raby and Richard Slansky

Family Mixing and the Origin of Mass—The Difference between

Weak Eigenstates and Mass Eigenstates 72

Stuart Raby

A Brief History of Neutrino Experiments at LAMPF 78

Gerry Garvey

At the end of the Los Alamos kilometer-long proton accelerator lies a unique neutrino facility, where the search for rare decays of the muon and for neutrino oscillations has been ongoing for over two decades. The research is now culminating in the first positive evidence for neutrino oscillations.

Tritium Beta Decay and the Search for Neutrino Mass 86

Tom Bowles and R. G. Hamish Robertson as told to David Kestenbaum

A Thousand Eyes—The Story of LSND 92

Bill Louis, Vern Sandberg, and Hywel White as told to David Kestenbaum

The first announcement of LSND's positive results for neutrino oscillations was greeted with blatant skepticism. Now, after two additional years of data collecting, the LSND collaboration has begun to convince the world of its results. Not one, but two systematically independent measurements say that the neutrino has mass.

The Evidence for Oscillations116*Bill Louis, Vern Sandberg, Gerry Garvey, Hywel White, Geoffrey Mills, and Rex Tayloe*

Neutrino oscillations are invoked as the explanation in experiments with solar, atmospheric, and accelerator-produced (LSND) neutrinos. This summary of the experimental results for mixing angles and neutrino masses includes an interesting model that makes all three data sets consistent.

The Nature of Neutrinos in Muon Decay and Physics Beyond the Standard Model128*Peter Herczeg*

Experiments that search for electron antineutrinos from μ^+ -decay are sensitive not only to neutrino oscillations but also to a class of muon decays that require leptonic interactions not present in the Standard Model. The author explores whether such decays could explain the observed excess of e^+ events in the LSND experiments.

Exorcising Ghosts—In Pursuit of the Missing Solar Neutrinos136*Andrew Hime*

Nearly all the electron neutrinos born in the Sun with a certain energy appear to vanish before ever reaching Earth. The enormous underground detectors that are currently in use have measured that absence, but the heavy-water detector at the heart of the SNO experiment may finally reveal where those neutrinos go.

The Russian-American Gallium Experiment152*Tom Bowles***MSW—A Possible Solution to the Solar-Neutrino Problem**156*S. Peter Rosen*

The “MSW effect” may dramatically enhance the oscillation of electron neutrinos into other neutrino types when the electron neutrinos pass through ordinary matter of a certain density. The author introduces the theory of this effect and its application to the solar neutrino problem.

Neutrinos and Supernovae164*Mark Herant, Stirling Colgate, Willy Benz, and Chris Fryer*

During the sudden collapse of a dying star, neutrinos become so abundant that they scatter, exert pressure, and in general, behave like a relativistic gas. The authors show how this neutrino gas powers a “convective engine,” reversing the collapse and, ultimately, blowing the star apart in the most powerful explosion known to man.

Dark Matter and Massive Neutrinos180*Salman Habib*

Strange as it may seem, the endless stars and myriad galaxies constitute but a tiny fraction of the total mass of the Universe. Though a neutrino with mass is often named as a promising candidate for the missing mass, models of structure formation suggest that neutrinos play only a minor role in the large-scale unfolding of the Universe.